Use of Direct Observation to Determine Habitat Utilization by a Freshwater Fish

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USE OF DIRECT OBSERVATION TO DETERMINE HABITAT UTILIZATION BY A FRESHWATER FISH.--Habitat utilization by lacustrine fish has been studied using one or more of the following techniques: (1) analysis of angling success (Paetz and Nelson, 1976), (2) tag-recapture studies (Makowecki, 1973) and (3) use of radio location telemetry (Diana et al., 1977; Chapman and Mackay, in press). The first two methods generate extensive data but may be biased by: (1) passive capture techniques, (2) nonrandom distribution of sampling effort, and (3) selectivity of sampling gear. Radio location telemetry can be used to produce intensive data on the individuals carrying transmitters but data are generally obtained from relatively few individuals.

Direct observation techniques have been extensively employed in studies of tropical marine fish, particularly coral reef communities, and has lead to a detailed understanding of the habitat requirements of those species studied. Direct observation has not been extensively utilized in freshwater lakes, presumably because visibility is often severely limited.

Some authors (Scott and Crossman, 1973; Makowecki, 1973) have claimed that pike exploit only a small number of habitats, and are usually restricted to vegetated shallows. These claims may be biased, because the methods used to examine habitat use preferentially selected for pike which were engaged in specific behaviours, associated with particular habitats. It is obvious that assessments of habitat utilization from angling success

will be biased toward habitats that pike select while foraging. Previous reports may also be biased simply because they were based on studies which did not evaluate all potential habitats with the same precision.

The objective of the present study was to assess habitat utilization by northern pike (*Esox lucius* L.), a large, solitary, freshwater fish, using direct observation techniques.

Methods.--Data were collected from July through September, 1980, in the deepest lake of Twin Lakes, Alberta (52°56'N, 114°20'W). The lake chosen is small (0.23 km^2), oligotrophic, with a narrow littoral zone and a maximum depth of over 40 m. The lake is situated in a valley, protected from the winds and had a sharp thermocline at about 8 m when the study was undertaken. Only 12% of the surface area of the lake was less than 2 m deep. From a survey conducted on August 16, 1980 it was determined that rooted aquatic vegetation was present under 11% of the surface of the lake. There was little rooted vegetation growing below the 2 m level. The major reason for choosing this lake was its good underwater visibility, which averaged 6 m.

Visual surveys were conducted by swimming along 100 m transects parallel to the depth contours of the lake basin. A single transect in each of 3 habitat zones was surveyed on 9 different occasions between July 6 and September 22, 1980. The 3 habitat zones were defined in relation to depth and vegetation; the first was in water less than 2 m deep, this area corresponded closely with the area containing rooted aquatic vegetation. The second transect was located in 2 to 4 m of water, which at Twin Lakes corresponds with a steep sloping bank. Both

of these transects were surveyed using snorkel, only the third transect, which was at a depth of 10 m, required use of SCUBA techniques. The surveys were done from approximately 1 m above the bottom, by looking forward, counting any fish which were within a 3 m wide field of view immediately in front of the observer. Thus the number of pike in a 300 m^2 area was determined for each transect. Every time a fish was seen its length, depth and presence or absence of rooted vegetation were recorded on an underwater slate.

Results.--A total of 238 northern pike were observed on the 9 occasions that the 3 transects were surveyed. Pike were commonly observed 3 to 4 m ahead of the diver and could be easily approached. Small pike often allowed the diver to approach within a meter of them, while larger pike were more wary, and would often flee before the observer got within 2 m. Large pike were often seen stationarily positioned at the macrophyte- open water interface, while small pike were rarely seen there. Occasionally large pike would follow or lead the diver along the transect, maintaining a fixed distance from the diver. Twelve percent of the surface area of the lake was less than 2 m deep. If pike choose habitats at random, 29 of the 238 sightings would be expected in this area however 192 pike were observed in shallow water, this difference is highly significant ($\chi^2 = 1066$, $p < 0.001$). Approximately 11% of the total area was underlain by rooted aquatic vegetation, 82% (195) of the pike were observed in this area ($\chi^2 = 1220$, $p < 0.001$). Thus pike showed a strong preference for shallow vegetated regions of the lake.

It was possible to estimate the length of the pike observed and thus to determine whether there was spatial segregation of large and small individuals. Small, sexually immature (< 30 cm) and large maturing (> 30 cm) pike showed a strong preference for shallow areas containing rooted aquatic macrophytes (Table 1). Small pike used shallow water habitats significantly more than large pike ($\chi^2 = 7.5$, $p < 0.01$) but the two size classes did not differ in their frequency of association with rooted macrophytes ($\chi^2 = 3.3$, $p > 0.05$). Some of the large pike found in more than 2 m of water were associated with the few macrophytes found there. The larger pike appear to be somewhat more versatile than small ones in that they utilized a wider range of habitats.

Since the lake was surveyed before and after the fall turnover, it was possible to investigate the effect of turnover on habitat selection of pike. In the four surveys before turnover 230 pike were sighted, after turnover only 8 individuals were seen on five surveys of the same area. As well as surveying the three transects, a large portion of the lake above 20 m was searched in an unsuccessful attempt to determine where the pike were. They could have moved into one of the small creeks which drained into the lake or they could have been in the area of the lake deeper than 20 m which was not surveyed. It is unlikely that avoidance distance of the pike was greater than human underwater visibility since the avoidance distance of the 8 pike seen was not significantly different from that of pike before turnover.

Discussion.--Using direct observation techniques we established that the northern pike studied utilized all of the habitats available to them but relied most heavily upon the shallow vegetated areas of the lake. Kipling and Frost (1970), and Diana et al. (1977) also found that pike utilized shallow vegetated areas in lakes quite different from Twin Lakes. This study revealed that large and small pike differ with regard to habitat selection. The smaller fish appear to be more strongly associated with the shallow vegetated areas, than the larger pike which, on average, used slightly deeper regions with less vegetation. Large pike were observed in areas which had water just deep enough to cover their bodies, as well as at depths of 20 m.

Since the size of prey decreases with predator size (Krebs, 1979) the habitat selected by each size class of pike may be related to the optimal prey size for each size of pike. Hoogland et al. (1956) and Nursall (1973) showed that the optimal prey size of pike is directly related to the pike's body size. Frost (1954) demonstrated that in Lake Windermere, smaller pike (less than 20 cm) fed predominantly on invertebrate species. Lawler (1965) showed that pike of similar size at Heming Lake, Manitoba, relied strongly on invertebrates as well as fish which were [commonly] thought to be predominantly found in shallow regions. Since invertebrates that are fed on by small pike are most abundant in shallow vegetated regions (Makowecki, 1973), it would seem that habitat selection by the different size classes of pike can be partially explained by the distribution of suitable prey.

Direct observation techniques allow the researcher to describe the interaction of individual fish with their environment, thus facilitating

a more complete understanding of the habitat association. In this study, through the direct observation of different size classes of pike, it was evident that each size class used different behavioural strategies. The smaller pike tended to utilize cover to hide from approaching divers, while the larger individuals choose to flee. Assuming that pike reacted to the divers as a potential predator, it is possible that the smaller pike use shallow vegetated habitats proportionally more than larger pike because the smaller fishes need this area to provide cover from potential predators. Since pike are cannibalistic, potential predators include large pike.

The change in pike distribution at Twin Lakes at the time of turnover provides limited evidence that limnological factors, namely the water temperature and dissolved oxygen content, influence pike's selection of habitat, though not necessarily directly.

We have used direct visual surveys of transects through 3 habitat zones to evaluate habitat use by northern pike. This technique could also be effectively used to estimate the population size of various species within lakes and rivers or to determine interspecific distribution patterns of suitably visible fish species. In order to ensure maximum quantification in such visual studies the transects used should be clearly defined by placing parallel ropes a fixed distance apart along the bottom of the lake and only counting those fish which have more than half of their body within the boundaries of the ropes.

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Table I. Numbers of small and large northern pike observed in water less than 2 m deep and the number observed in association with rooted macrophytes. The total number of fish seen in each size class is indicated by n.

Size Class (cm)	n	< 2 m of Water	Rooted Macrophytes
< 30	190	160	160
> 30	48	32	35